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DISCUSSION OF PROCEEDINGS PAPERS

476, 516, 756

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Discussion of
"STUDIES OF BEARPAW SHALE AT A DAMSITE IN SASKATCHEWAN"

by Robert Peterson
(Proc. Paper 476)

ROBERT PETERSON,[1] M. ASCE.—The discussion of Dr. Mayer and the information which he has presented on the Paris clay is very much appreciated. The similarity between the Paris clay and the soft and medium zone of the Bearpaw shale is most interesting.

The author is very grateful to Dr. Mollard and Mr. Pollock for their comprehensive discussion which adds to and clarifies the limited amount of geological information given in the original paper. The geology of the area in question is extremely involved and much painstaking work coupled with an excellent appreciation of glacial geology has been required to piece together the rather complicated sequence of events. The writer would like to comment on two points from this discussion.

Under the heading Geologic Setting in Slide Areas it is stated that three conditions appear necessary before large slumps are produced and "moreover, that the absence of any one condition results in slope movement that is negligible, if it can be discerned at all:." The author is not convinced that the second condition listed, that is "a mantle of glacial drift deposited upon clay shales" is necessary before large slumps are produced. While all the slides studied did occur in areas that are covered or have been covered by drift, there was no opportunity to make observations of slopes that had not been affected by glaciation. It is therefore rather difficult to support a definite conclusion about the effect of this mantle of glacial drift on slumping in this region.

The second point has to do with the field measurements from which it has been concluded in this discussion that "local areas in the slump terrain are creeping at the apparent rate of approximately 3 inches per decade." While the observations referred to have been taken very carefully there is some question as to definite conclusions because of the difficulty of establishing reliable reference points along the unstable river slopes. In view of the fact that the design of the shale slopes on the project, and for that matter the cross-section of the embankment itself, will in the final analysis be based on the shear strength computed from natural slopes, further study is being given this matter. In order to arrive at shear strengths based on natural slopes some knowledge of the rate of creep, if any, is of paramount importance. It has therefore been suggested that steps be taken to check the rate and depth of creep utilizing vertical plastic tubes and the Slope Indicator developed by Mr. S. D. Wilson and described in Separate No. 475 entitled: "Safe Loads on Dog-Leg Piles."

Mollard and Pollock have asked about the results of creep strength tests referred to in the original paper. From a limited number of unconfined creep

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strength tests at constant water content, a strength as low as 50 percent of the conventional unconfined compression strength was recorded.

Since the original paper was presented additional pressure observations have been taken and further studies have been made in connection with the accuracy of the measuring equipment in the pressure test section. The most recent readings about four years after the installation of the pressure test section indicate that the vertical pressure produced by the shale is approximately equal to overburden and that the horizontal pressure is of the order of 147 percent of overburden. This is an increase in horizontal pressure over that reported in the original paper, the values of which were for an interval of two years following installation. All the struts have been removed and recalibrated and it is now believed that the forces measured by this system are within 10 percent of the actual forces exerted. It is therefore believed that this method is entirely satisfactory for measuring the relation of horizontal and vertical stresses within soft shales or soils.

Correction to "Studies of Bearpaw Shale at a Damsite in Saskatchewan" (Proc. Paper 476).

On page 11, at the end of the second paragraph, the sentence beginning "The shear strength based on these assumptions * * *" should read: "The shear strength based on these assumptions and for a factor of safety of 1 was of the order of 3 - 4 lb per sq. in."

Discussion of
"ENGINEERING PROPERTIES OF EXPANSIVE CLAYS"

by W. G. Holtz and H. J. Gibbs
(Proc. Paper 516)

W. G. HOLTZ,[1] M. ASCE, and H. J. GIBBS,[2] A.M. ASCE.—The authors wish to thank the discussors of their paper and feel that each has contributed to the subject by his comments.

In regard to Professor Dawson's comments that the Atterberg tests are more reliable indicators of swell characteristics than the free-swell test, the authors agree and wish to further point out that the free-swell tests were considered applicable only for indicating general trends by simple procedure. Tests which are more closely controlled of course are better indicators. The index table given in the paper has similarity to Skempton's activity values in that both involve particle size and Atterberg constants; however, Skempton's activity value is arrived at through a graphical plot.

The authors also agree with Professor Dawson that a slight relief of expansion movement greatly reduces the swelling pressures. This was shown in the paper by Figure 9 when expansive soil was compacted at variable densities, and measured for uplift pressure, and by Figure 5 which shows the amounts of expansion for various restraining loads.

Mr. Altmeyer points out similarity in his criterion based on the shrinkage limit with the portion of the authors' criteria in which the shrinkage limit was used. The similarity of the independent conclusions are of interest to us. However, we believe the similarity to be factual rather than coincidental. It should be noted that Mr. Altmeyer's soil is also from the California area and thus may be similar to the soils from which much of the authors' data were obtained. In view of the fact that soils from other areas may act differently, the authors felt that index to expansion should be based on more than the shrinkage limit and therefore also included the percentage of colloids, and plasticity index as additional indicators which must be viewed together. By viewing these items together a fairly reliable evaluation of expansion can be made, in spite of the overlap of limits for individual items in the table.

The authors wish to point out that the classification system referred to by Mr. Altmeyer is the same as that used by the authors. The Unified Soil Classification was sponsored jointly by the Corps of Engineers and the Bureau of Reclamation.[3]

Mr. Barber shows some interesting data comparing the swell of soils of various classifications such as the high swell obtained by an A-6 soil (Bureau

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3. Unified Soil Classification, a Supplement to the Earth Manual; U. S. Department of the Interior, Bureau of Reclamation, March 1953.

of Public Roads Classification) in comparison to other types. He also shows the reduction of uplift pressure by the slight relief of expansion as did Professor Dawson.

The authors agree with Professor DuBose that placement conditions of expansive soil should vary as the surcharge decreases from lower layers to the top of the fill. Laboratory load-expansion tests would show this requirement. For a certain soil, expansion may have a time relationship as Professor DuBose has shown. The authors have experienced distinctly different speeds of expansion for different soils. This is believed due to differences in water affinity which, in turn, is affected by mineral and chemical characteristics and may vary greatly in different soils.

Discussion of
"SETTLEMENT ANALYSIS OF SAND DRAIN PROJECTS"

by Edward A. Henderson
(Proc. Paper 756)

GEORGE R. HALTON,[1] M. ASCE.—The author's straightforward and factual presentation of settlement analysis on two highway sand drain projects properly avoids subjects such as field measurement of pore pressure, stability during embankment construction and other allied topics which are in themselves worthy of separate papers.

By the same token this short discussion of the author's paper should not explore allied subjects; at best it should touch on a few high points within the scope of the original and within the writer's experience, which in this case includes, while with O. J. Porter & Co., assisting in construction consultation at Point Pleasant and in design consultation at Camden.

An important phase of construction control at Point Pleasant, as on most sand drain projects, was the analysis of movements in offset stakes. The plots of these against time were periodically compared with the settlement vs. time pattern. Concomitant accelerations of vertical and horizontal movements or simply an abnormal lateral displacement were danger signals; isolated vertical irregularities were merely alert signals. No definite numerical ratio of lateral deformation to settlement was used as a guide. Interpretation was then, and still is, largely a matter of judgment.

The probable relation of horizontal deformation to settlement is mentioned by the author without either a qualitative or a quantitative estimate of this component of settlement. In this connection the writer finds that the probable deformations consistent with Boyle's Law and Poisson's ratio are of interest:

1. Gas void compression is considerable when saturation is less than about 95%.
2. Horizontal movement greater than that computed from Poisson's ratio can reasonably be expected.

Field observations show difficult penetration of closed end mandrels in soft mud when spacing is close or where the periphery is driven before the center. Similar phenomena are noted in driving ordinary piles: for example, heaving or shoving of adjacent railroad tracks. This factor is significant in settlement analysis of sand drain projects when the volume of the sand columns approaches or exceeds the total volume of gas voids in the soil.

The true saturation of a submerged soil can be reckoned by a statistical average of many tests if the test data are accurate in this respect. However, because laboratory values depend on so many variables—salinity of pore water, specific gravity, organic content and disturbance or expansion or evaporation of a sample during field recovery or laboratory preparation—the true saturation and therefore the volume of gas, in a prototype mass of soil is rarely known.

1. Cons. Engr., George R. Halton Engr. Consultants, Newark, N. J.

Data from two consolidation tests of Point Pleasant samples recently made available to the writer showed volumes of gas voids 5 to 10 times as much as that suggested by observed settlement. It is deduced that evaporation and expansion occurred between sample recovery and specimen preparation. Concluding this sub-topic, determination of gas void volume is recommended for any sand drain project contemplating close (6' to 8' o.c.) spacing.

The Poisson's ratio aspect is of interest because of boundary restraints. The effect of rigid boundaries on component or induced stresses and deformations is analyzed in engineering literature. Published data furnishes evidence of this effect: for example Spangler's measurement of horizontal stresses against a retaining wall induced by vertical loads.

The old causeway along one side of the Point Pleasant fill provided a partial transverse restraint; the near semi-infinite strip shape of the embankment furnished longitudional restriction.

The writer estimates that the partial boundary restraints at Point Pleasant accounted for horizontal deformations approximating two thirds of the non-hydraulic component of settlement and that the non-hydraulic component was of the order of one foot.

A final note regarding the time vs. settlement plots on both projects, or on any sand drain job, is worthy of mention. When time is plotted arithmetically and the percent of total settlement is plotted as an inverse logarithm, portions of the plot are straight lines. Definite changes in the slopes of these lines are noted at or shortly after application of the final increment of load. This is seen in Fig. 12 in both the Point Pleasant and the Camden plots. This method of plotting has other advantages:

1) Calendar time, instead of number of days after this or that operation, can be plotted conveniently;
2) Extrapolation of straight lines to zero settlement or to load equilibrium settlement indicates approximate midpoint of loading cycle;
3) Settlement can be equated to gain in intergranular pressure, which is equal to decrease in pore pressure.

The latter advantage is of value in estimating stability during construction.

In conclusion, the writer confirms the author's conclusions and emphasizes the recommendation that Field decisions during construction should control the intensity and duration of overload.

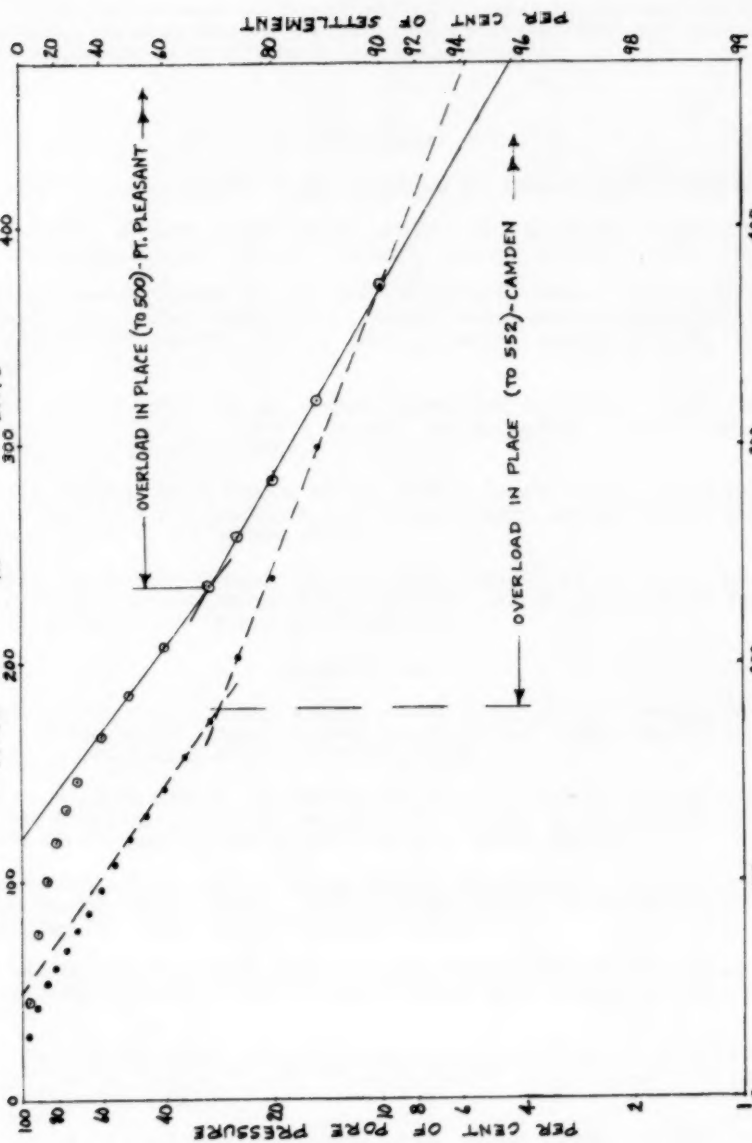

FIG. 12 - SETTLEMENT VS. TIME

PROCEEDINGS PAPERS

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c. Discussion of several papers, grouped by Divisions.

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